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(54) Inflator

(57) In order to provide an inflator including a piston which can reliably break a burst disk (sealing plate) with a small force, an inflator (1) according to the present invention includes a piston (13) which is two-forked at an end thereof and is provided with two cutting edges (35). The cutting edges (35) of the piston (13) come into contact with portions of a sealing plate (5) which swells toward the piston (13) side by being pushed by a high-pressure gas stored in a bottle (3), the portions being offset from the vertex of the swelling sealing plate (5). Each cutting edge (35) is tapered at the outer side thereof (the side away from the vertex of the sealing plate), and the tip of the cutting edge is thereby positioned at the inner side of the periphery of the piston (13). The angle formed between the axis of each cutting edge (35) and the surface of the sealing plate (5) is increased. Therefore, the cutting edges (35) can smoothly cut into the swelling sealing plate (5). Deformation of the cutting edges (35) toward the outside and slip thereof along the spherical surface can be suppressed.

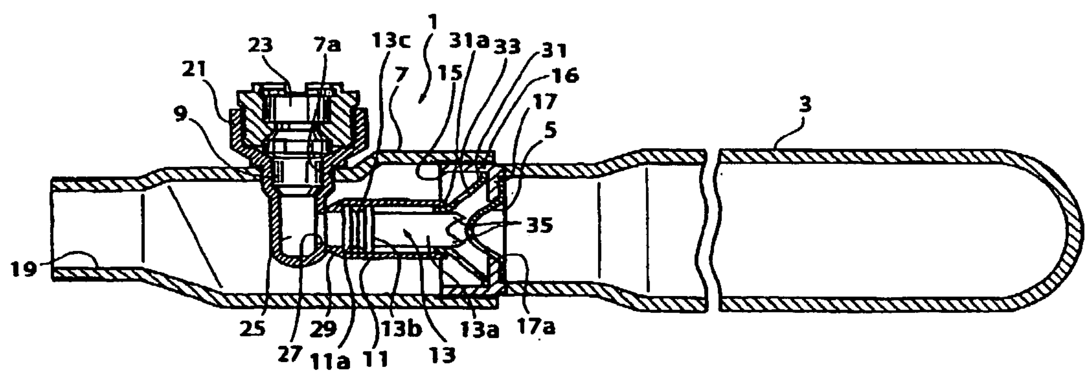

Fig. 1

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Description

[Technical Field of the Invention]

[0001] The present invention relates to an inflator for generating gas for inflating and deploying an airbag.

[Description of the Related Art] -

[0002] As a gas generator for deploying an airbag, a type (combustion type) of inflator which burns a gas-generating agent (propellants) and generates gases by chemical reaction, and another type (stored-gas type) of inflator which ejects a high-pressure gas stored in a container are known.

[0003] A stored-gas-type inflator is shown in Fig. 5.

[0004] Fig. 5 is a schematic longitudinal-sectional view of a known stored-gas-type inflator which is disclosed in, for example, Japanese Unexamined Patent Application Publication No. 10-250525.

[0005] An inflator 100 includes a bottle 101 to be charged with a high-pressure gas. A sleeve 109 is connected at an opening 103 of the bottle 101 via a ring 106. The ring 106 is provided with an aperture 106a formed at a central part of the ring 106.

[0006] A burst disk (sealing plate) 107 is mounted by welding or the like to the left-surface side (the sleeve 109 side) of the ring 1.06. The burst disk 107 is made of steel and has a thickness of approximately 0.3 mm. The burst disk 107 swells toward the sleeve 109 side by being pressed with the pressure of the gas stored in the bottle 101, as shown in the drawing.

[0007] A plurality of gas outlets 104 through which the high-pressure gas in the bottle 101 is ejected when the inflator 100 operates are formed in the sidewall of the sleeve 109. A housing 110 mates with the sleeve 109 at an end (the left side open end in the drawing) thereof. The housing 110 includes an initiator fixing part 110a and a cylinder 110b protruding from the fixing part 110a. The fixing part 110a is affixed and held by the sleeve 109 at the end thereof, an initiator 112 being embedded in the fixing part 110a. An end (right side end) 112a of the initiator 112 is inserted into the cylinder 110b.

[0008] A piston 115 is disposed in the cylinder 110b of the housing 110. An end 115a of the piston 115 is tapered in a cone-shape. The piston 115 is provided with a hole 115b formed in the rear end of the piston 115. The end 112a of the initiator 112 is inserted into the hole 115b. The burst disk 107 is disposed at a predetermined distance from an end 110c of the cylinder 110b of the housing 110.

[0009] The gas outlets 104 of the inflator 100 communicate with an airbag body (not shown). In a normal state, a gas fills the bottle 101 and is sealed in the bottle 101 with the burst disk 107. When the automobile receives an impact, a sensor (not shown) operates and the initiator 112 generates a gas blast. The gas blast presses the piston 115 to the right in the drawing, and the end 115a of the piston 115 breaks the burst disk 107 at a central part thereof. Then, the high-pressure gas filling the bottle 101 is ejected and is supplied into the airbag body from the inside of the sleeve 109 through the gas outlets 104 formed in the peripheral surface of the sleeve 109.

[0010] The end 115a of the piston 115 must be keen-edged so that the piston 115 reliably breaks the burst disk 107. In the above example, the end 115a is formed tapered in a cone-shape.

[0011] A gas generator used in an inflator or the like is disclosed in, for example, Japanese Unexamined Patent Application Publication Nos. 5-201304, 10-138862, and 12-250525, in which a piston of the gas generator is formed as a cylinder, a cone, and a pyramid (polygonal), respectively.

[0012] Fig. 6 shows another shape of the end of the piston.

[0013] The end of the piston may be formed as a needle shown in Fig. 6(A), as a cylinder shown in Fig. 6(B), or as a punch shown in Fig. 6(C).

[0014] The needle includes a needle 121 having a fine tip. The cylinder includes a cylinder 123 provided with a circular recess formed at an end thereof so as to form a cutting edge 125 around the periphery. The punch includes a cylinder 127 which is two-forked at an end thereof to form two cutting edges 129.

[Problems to be Solved by the Invention]

[0015] It is generally understood that the punch-shaped two-forked end is most effective among the above shapes of the piston for reliably breaking the sealing plate with a smallest force. The punch-shaped piston cuts into the burst disk at two positions thereof away from the vertex of the swelling burst disk.

[0016] However, the two-forked punch-shaped piston has a problem described below.

[0017] Fig. 7 is a schematic view of the two-forked punch-shaped piston being deformed at an instant when the piston comes into contact with the burst disk.

[0018] Although the piston is disposed so that an axis 131 thereof associates with the vertex of the burst disk swelling in a spherical shape, the tip of each cutting edge 129 is offset to the outside from the axis 131 of the piston. Therefore, when the piston comes into contact with the spherically swelling burst disk, the tips of the two cutting edges 129 come into contact with the burst disk at positions away from the vertex thereof. As a result, the cutting edges are not applied thereto at a right angle and are applied thereto at a smaller angle (see Fig. 3). Then, the cutting edges 129 sometimes slide on the surface of the burst disk and are bent toward the outside, as shown by dotted lines in the drawing (reference numeral 129'). Therefore, the cutting edges do not sharply cut and there is a risk of causing a problem in that the burst disk is not broken smoothly.

[0019] Accordingly, an object of the present invention

is to provide an inflator including a piston which is capable of reliably breaking a burst disk (sealing plate) with a small force.

[Means for Solving the Problems]

[0020] According to the present invention, this object is achieved by an inflator as defined in claim 1. The dependent claims define preferred and advantageous embodiments of the invention.

[0021] To this end, according to the present invention, an inflator comprises a bottle provided with an opening, to be charged with a high-pressure gas; a sealing plate for sealing the bottle at the opening thereof; an initiator for generating a gas blast as a motive force to break the sealing plate; and a punch (piston) including a cutting edge for breaking the sealing plate, the punch accelerating with the gas blast of the initiator. The sealing plate swells toward the punch by being pressed by the high-pressure gas. The cutting edge of the punch comes into contact with a portion of the sealing plate offset from the vertex of the swell of the sealing plate. The cutting edge is provided with a tapered face formed at the outer side of the cutting edge (at the side away from the vertex of the sealing plate).

[0022] Since the cutting edge of the punch is tapered, the tip of the cutting edge is positioned inside the periphery of the punch. An angle between the central line of the cutting edge and the surface of the sealing plate is increased. Therefore, the cutting edge properly cuts into the swelling sealing plate, and deformation of the cutting edge toward the outside and side slip along the spherical surface of the sealing plate are suppressed, thereby reliably breaking the sealing plate.

[0023] According to the present invention, the tapered face is preferably formed so as to have an angle smaller than an angle α of friction with respect to the normal line on a contact point between the cutting edge and the sealing plate, the angle α of friction being determined in accordance with the materials of the punch and the sealing plate. The length (in the axial direction of the punch) of the tapered face is preferably set to 0.5 mm or greater. With the arrangement of the shape and the size as described above, the cutting edge can effectively and reliably break the sealing plate.

[Brief Description of the Drawings]

[0024]

Fig. 1 is a longitudinal-sectional view of an inflator according to an embodiment of the present invention.

Fig. 2 includes illustrations of a piston of the inflator shown in Fig. 1. Fig. 2(A) is a side view of the entire piston. Fig. 2(B) is an expanded side view of the tip of the piston.

Fig. 3 includes illustrations showing a state in which cutting edges of the piston are in contact with a sealing plate which swells in a spherical shape. Fig. 3 (A) is one of the illustrations showing the whole. Fig. 3(B) is the other illustration showing the relationship of angles between each part.

Fig. 4 includes illustrations showing the operation of the inflator shown in Fig. 1. Fig. 4(A) shows the operation of the piston. Fig. 4(B) shows a state in which high-pressure gas is ejected.

Fig. 5 is a schematic longitudinal-sectional view of a known stored-gas-type inflator disclosed in, for example, Japanese Unexamined Patent Application Publication No. 10-250525.

Fig. 6 includes illustrations of other examples of tips of the piston.

Fig. 7 is a schematic view of a two-forked punch-shaped piston being deformed at an instant when the piston comes into contact with a burst disk.

[Description of the Embodiments]

[0025] Embodiments are described below with reference to the drawings. In the specification, directions are referred to (such as, to the left or the right, and upper or lower) with reference to the drawings.

[0026] Fig. 1 is a longitudinal-sectional view of an inflator according to an embodiment of the present invention.

[0027] An inflator 1 includes a bottle 3, a sealing plate (burst disk) 5, a diffuser 7, an initiator 9, a barrel 11, and a piston (punch) 13 as major components.

[0028] The bottle 3 is made of steel and is formed as a cylinder with a bottom. The bottle 3 is charged with a high-pressure inactive gas or the like. A ring-shaped annular member 16 is connected to the left end (open end) of the bottle 3 in the drawing. A flange 17 is formed protruding to the inside of the annular member 16 at the bottle 3 side thereof. The flange 17 forms an aperture 17a at a central part thereof. The annular member 16 is straight open at a left end 15 thereof in the drawing.

[0029] The sealing plate 5 is fixed to the right side of the flange 17 of the annular member 16 by welding or the like from the inside of the bottle 3. The sealing plate 5 is a flat disk made of, for example, steel, and has a thickness of, for example, 0.4 mm. The sealing plate 5 is planar when the bottle 3 is not charged with high-pressure gas, and swells in a spherical shape toward the outside of the bottle 3 from the aperture 17a of the flange 17 when the bottle 3 is charged with the high-pressure gas.

[0030] The diffuser 7 is made of, for example, steel and is formed in a cylindrical shape, both ends thereof being open. The end 15 of the annular member 16 is

fixed to the right end of the diffuser 7 by screwing. The left end of the diffuser 7 serves as an outlet 19 of the high-pressure gas. The gas outlet 19 is connected to an airbag that is not shown. A through-hole 7a is formed in the upper side of the diffuser 7. A housing 21 is inserted into and affixed at the through-hole 7a. An ignition plug 23 and the initiator 9 are mounted in the housing 21. The housing 21 is provided with a space 25 formed at a lower part of the housing 21, which extends substantially to the center of the diffuser 7. The housing is provided with a through-hole 27 in the sidewall at a lower part and at the bottle side of the housing.

[0031] The cylindrical barrel 11 is connected to the lower part of the housing at the through-hole 27 thereof. An inner hole 11a of the barrel 11 communicates with the space 25 of the housing 21. The barrel 11 extends toward the bottle 3 along the axis of the bottle 3. A step 29 with which the piston 13 to be described below comes into contact at a larger diameter part 13b thereof is formed inside the barrel 11 at the left end thereof. The inner wall of the inner hole 11a of the barrel 11 extends from the right side of the step 29 to the right end of the barrel 11, the inner hole 11a being open at the right end of the barrel 11. The barrel 11 is connected to the inner face of the flange 17 of the bottle 3 at the right end (bottle side end) of the barrel 11 via a supporting plate 31. The supporting plate 31 is formed as a frustum of cone and is provided with a plurality of through-holes 33 formed therein. These through-holes 33 serve as paths for gas from the inside of the bottle 3 to the inside of the diffuser 7 when the sealing plate 5 is broken. A left end 31a of the supporting plate 31 is inserted into the right end of the inner hole 11a of the barrel 11, thereby forming a step in the inner hole 11a.

[0032] The piston 13 made of stainless steel or the like is slidingly disposed in the barrel 11. The piston 13 includes a head 13a at the right end (the bottle side end) and the larger diameter part 13b at the left end (the housing side end) of the piston 13. The head 13a has an outer diameter smaller than the inner diameter of the barrel 11 and the end of the head 13a is two-forked (details are described below). The larger diameter part 13b has an outer diameter substantially the same as the inner diameter of the barrel 11. A ring groove 13c is formed in an intermediate portion of the larger diameter part 13b. The left end of the larger diameter part 13b of the piston 13 is in contact with the step 29 disposed at the rear side of the barrel 11 in a normal state. The head 13a is positioned away from the sealing plate 5.

[0033] Fig. 2 includes illustrations of the piston of the inflator shown in Fig. 1. Fig. 2(A) is a side view of the entire piston. Fig. 2(B) is an expanded side view of the tip of the piston.

[0034] As described above, the piston 13 includes the head 13a and the larger diameter part 13b. According to the present embodiment, a diameter d1 of the head 13a is 8 mm. A diameter d2 of the larger diameter part 13b is 10 mm. The tip of the head 13a is two-forked and is provided with two cutting edges 35. A depth e1 of a bottom 37 between the two cutting edges 35 from the tip of the piston is 3 mm. The bottom 37 is formed such that the radius of a curved surface of the bottom becomes R1.5. The length e2 of the larger diameter part 13b along the axis of the piston is 4 mm.

[0035] A tapered face 41 inclined toward the inside from the peripheral surface 39 of the piston is formed at the outer side of each cutting edge 35, as shown in an expanded view in Fig. 2(B). Each cutting edge 35 is formed with the tapered face 41 and an inclined face 43 disposed at the inside. A distance e3 between the two cutting edges 35 is 6 mm. A length e4 of each cutting edge 35 (the length of the tapered face 41) in the axial direction of the piston is 1.5 mm.

[0036] The angle of the tapered face 41 is described below.

[0037] Fig. 3 includes illustrations of the cutting edges of the piston in contact with the sealing plate swelling in a spherical shape. Fig. 3(A) is one of the illustrations showing the whole. Fig. 3(B) is the other illustration showing in detail the relationship of angles between each part.

[0038] A taper angle θ shown in Fig. 3(A) is defined as an angle between the peripheral surface 39 extending in the longitudinal direction of the piston (parallel to the axis of the piston) and an elongation T of the tapered face 41.

[0039] A method for forming the tapered face 41 is described below with reference to Fig. 3(B).

[0040] An angle α of friction is obtained from a coefficient μ of friction obtained in accordance with the material of the piston 13 and the material of the sealing plate 5, in which $\tan\alpha=\mu$. Symbol β represents an angle between the tapered face 41 and a normal line A on a contact point P between each cutting edge 35 and the sealing plate 5. The tapered face 41 is disposed at the piston 13 side of the normal line A such that the angle β between the tapered face 41 and the normal line A becomes smaller than the angle α of friction. The tapered face 41 may be disposed at the side opposite to the piston 13 with respect to the normal line A (in an opposite direction of the angle α of friction), unless the angle β becomes an obtuse angle.

[0041] When symbol γ represents an angle between a line B disposed on the axis of the piston 13 and on a center O of a spherical surface C formed with the sealing plate 5 and the normal line A disposed on the contact point P between the cutting edge and the sealing plate, the taper angle θ equals the difference between the angle γ and the angle β.

[0042] Therefore, when the angle α of friction is obtained from the materials of the piston 13 and the sealing plate 5, the angle β, which is smaller than the angle α, is determined. Then, the angle γ is obtained from the distance e3 (see Fig. 2(A)) and the radius R of the spherical surface of the sealing plate. The taper angle θ is obtained by subtracting the angle β from the angle γ.

[0043] The details may be reviewed, so that the taper angle θ satisfies the above-described condition (β<α), after the sizes shown in Fig. 2(A) are roughly set. That is, the taper angle θ can be obtained when the length e4 of the tapered face 41 in the axial direction of the piston and a length e7 (=(d1-e3)/2) of the tapered face 41 in the radial direction of the piston are set. The angle γ is obtainable from the distance e3 between the two cutting edges of the piston and the radius R of the spherical surface C of the sealing plate. The angle β can be obtained by subtracting the angle θ from the angle γ. Each size may be controlled so that the angle β becomes the same as or smaller than the angle θ. According to the present embodiment, the assumed friction coefficient μ = 0.4, the angle α of friction = 21.8°, and the taper angle = 20°.

[0044] The operation of the inflator is described below.

[0045] Fig. 4 includes illustrations showing the operation of the inflator shown in Fig. 1. Fig. 4(A) shows the movement of the piston. Fig. 4(B) shows the inflator when the high-pressure gas is ejected.

[0046] When an impact is applied to the automobile, the ignition plug 23 of the inflator 1 starts to operate. The ignition plug 23 ignites the initiator 9. A blast is applied by the initiator 9 to the space 25 disposed at the lower part of the housing 21. The blast goes into the barrel 11 through the through-hole 27 disposed at the lower part of the housing, and presses the piston 13 toward the bottle 3 along the axis of the barrel 11. Then, the cutting edges 35 of the piston 13 cut into the sealing plate 5 and break the same at a portion thereof corresponding to the tip of the piston 13. The piston 13 is pushed out toward the bottle 3 until the larger diameter part 13b of the piston 13 anchors at the end 31a of the supporting plate 31 (see Fig. 4(A)). Since the larger diameter part 13b of the piston 13 has a given length, the piston 13 moves stably in the barrel 11 along the axis thereof.

[0047] Since the angle θ of each tapered face of the head 13a of the piston 13 is set as described above, the tips of the cutting edges 35 do not slip on the surface of the sealing plate 5 when breaking the sealing plate. The cutting edges 35 cut into the sealing plate 5 such that they pierce into the sealing plate 5. Therefore, the cutting edges 35 do not bend toward the outside and can reliably break the sealing plate 5.

[0048] When the sealing plate 5 is broken, the piston 13 is pushed to the left in the drawing with the pressure of the high-pressure gas stored in the bottle 3, back to the position where the larger diameter part 13b of the piston 13 is anchored at the step 29 disposed inside the barrel 11. The high-pressure gas which has been stored in the bottle 3 flows into a space between the flange 17 and the supporting plate 31 through a part 5a of the sealing plate 5 at which the sealing plate 5 was broken, goes into the diffuser 7 through the through-holes 33 of the supporting plate 31, and is discharged through the gas outlet 19.

[Advantages]

[0049] As described above, according to the present invention, an inflator capable of breaking a sealing plate (burst disk) reliably and efficiently with each cutting edge of a piston including a tapered face can be provided.

Claims

1. An inflator (1) comprising:

    a bottle (3) provided with an opening, to be charged with a high-pressure gas;
    a sealing plate (5) for sealing the bottle (3) at the opening thereof;
    an initiator (9) for generating a gas blast as a motive force to break the sealing plate (5); and
    a punch (13) including a cutting edge (35) for breaking the sealing plate (5), the punch (13) accelerating with the gas blast of the initiator (9),

    wherein the sealing plate (5) swells toward the punch (13) by being pressed by the high-pressure gas;
    wherein the cutting edge (35) of the punch (13) comes into contact with a portion of the sealing plate (5) offset from the vertex of the swell of the sealing plate (5); and
    wherein the cutting edge (35) is provided with a tapered face (41) formed at the outer side of the cutting edge (35).

2. An inflator (1) according to Claim 1, wherein the tapered face (41) is formed so as to have an angle smaller than an angle α of friction with respect to the normal line (A) on a contact point between the cutting edge (35) and the sealing plate (5), the angle α of friction being determined in accordance with the materials of the punch (13) and the sealing plate (5).

3. An inflator (1) according to one of Claims 1 and 2, wherein the length in the axial direction of the punch (13) of the tapered face (41) is set to 0.5 mm or greater.

4. An inflator (1) according to one of Claims 1-3, wherein the punch (13) has the shape of a piston.

5. An inflator (1) according to one of Claims 1-4, wherein the cutting edge (35) is provided with the tapered face (41) formed at the outer side of the cutting edge (35) at a side away from a vertex of the sealing plate (5).

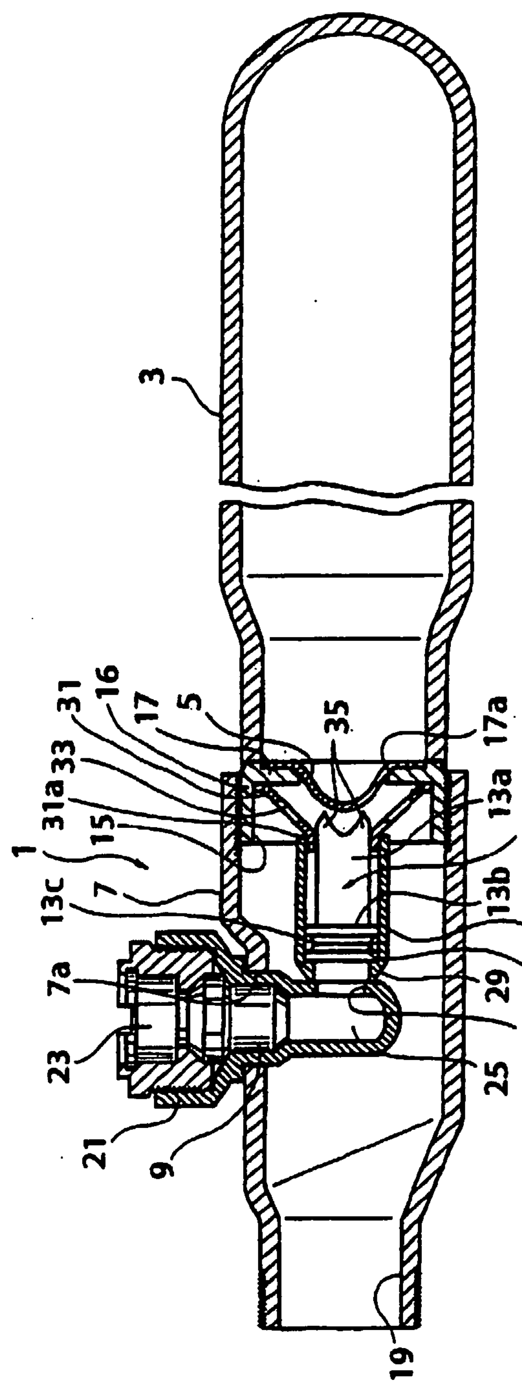
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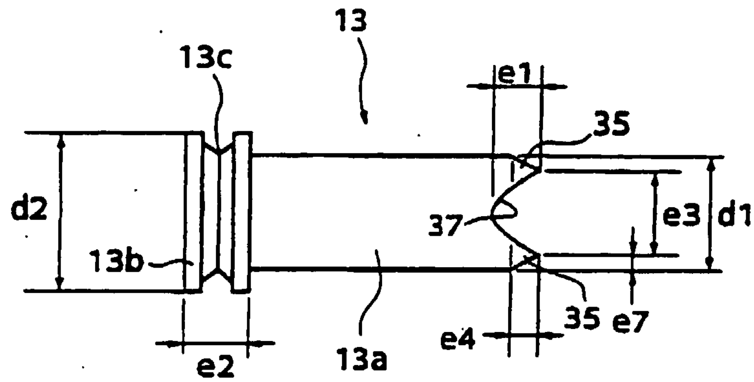
Fig. 1

(A)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(B)

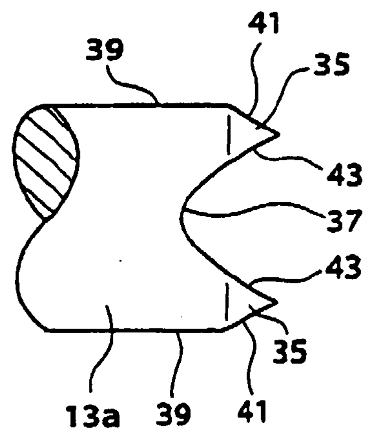
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Fig. 2

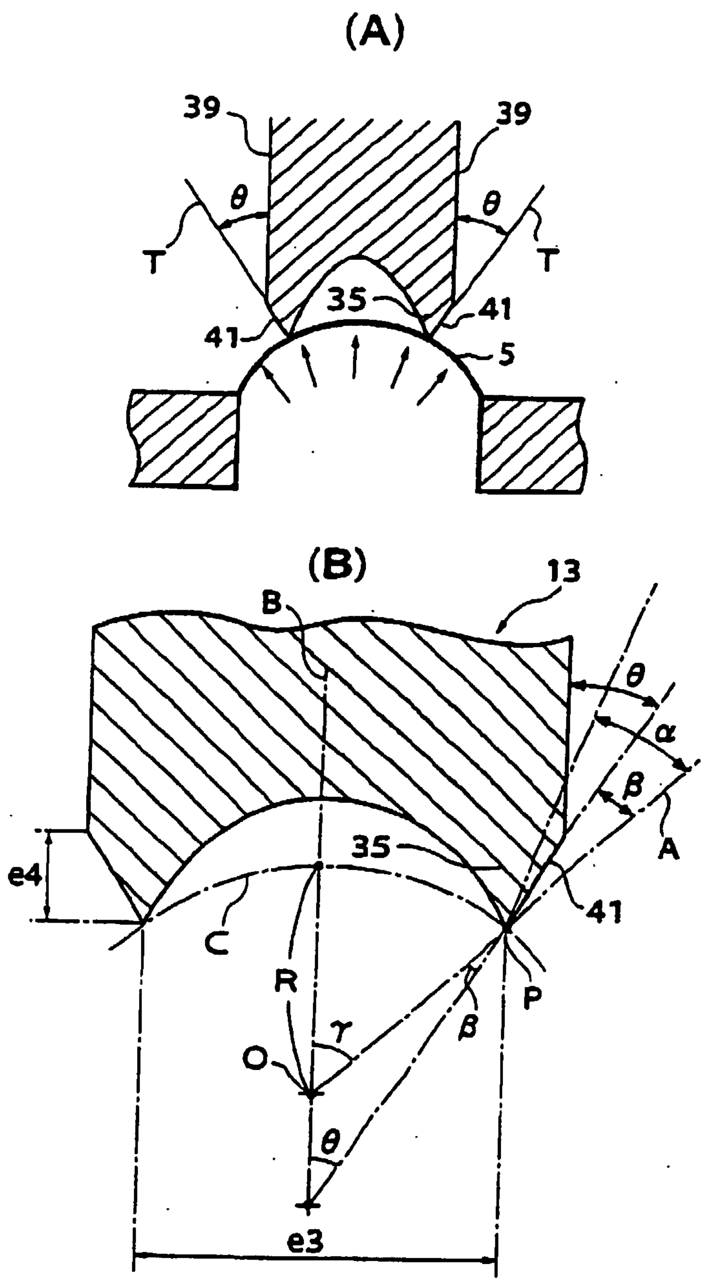
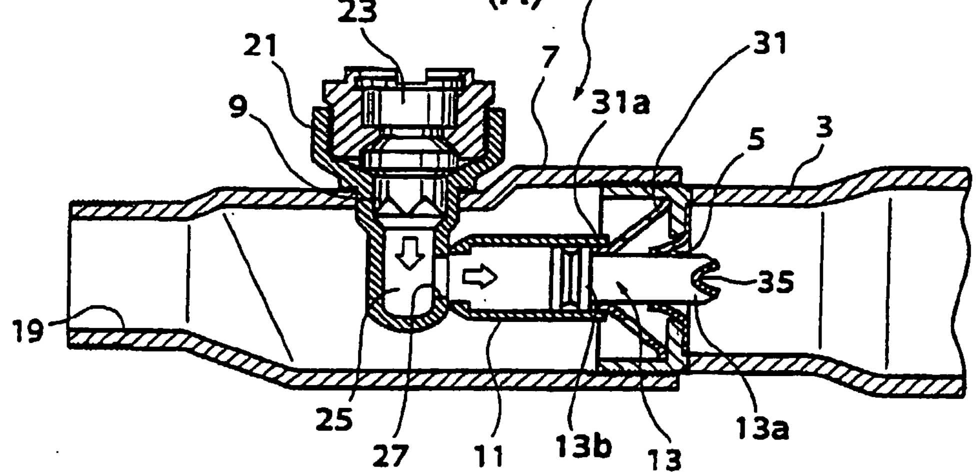


Fig. 3

(A)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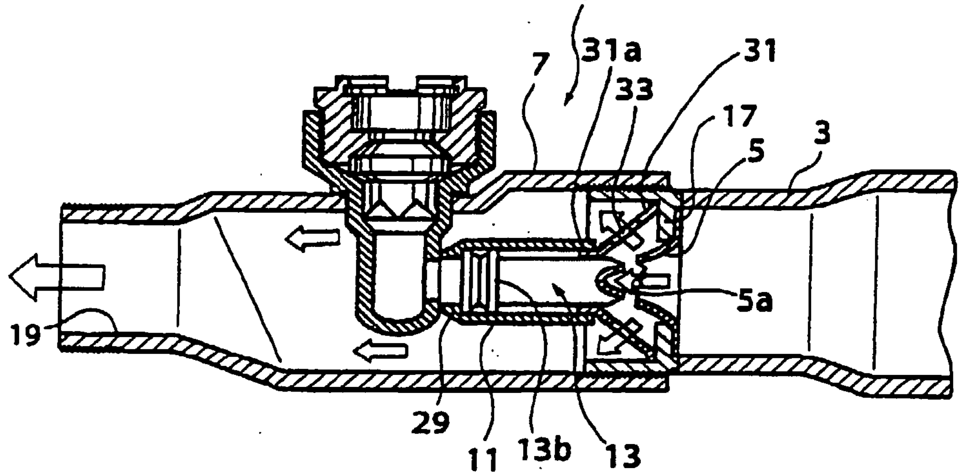
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Fig. 4

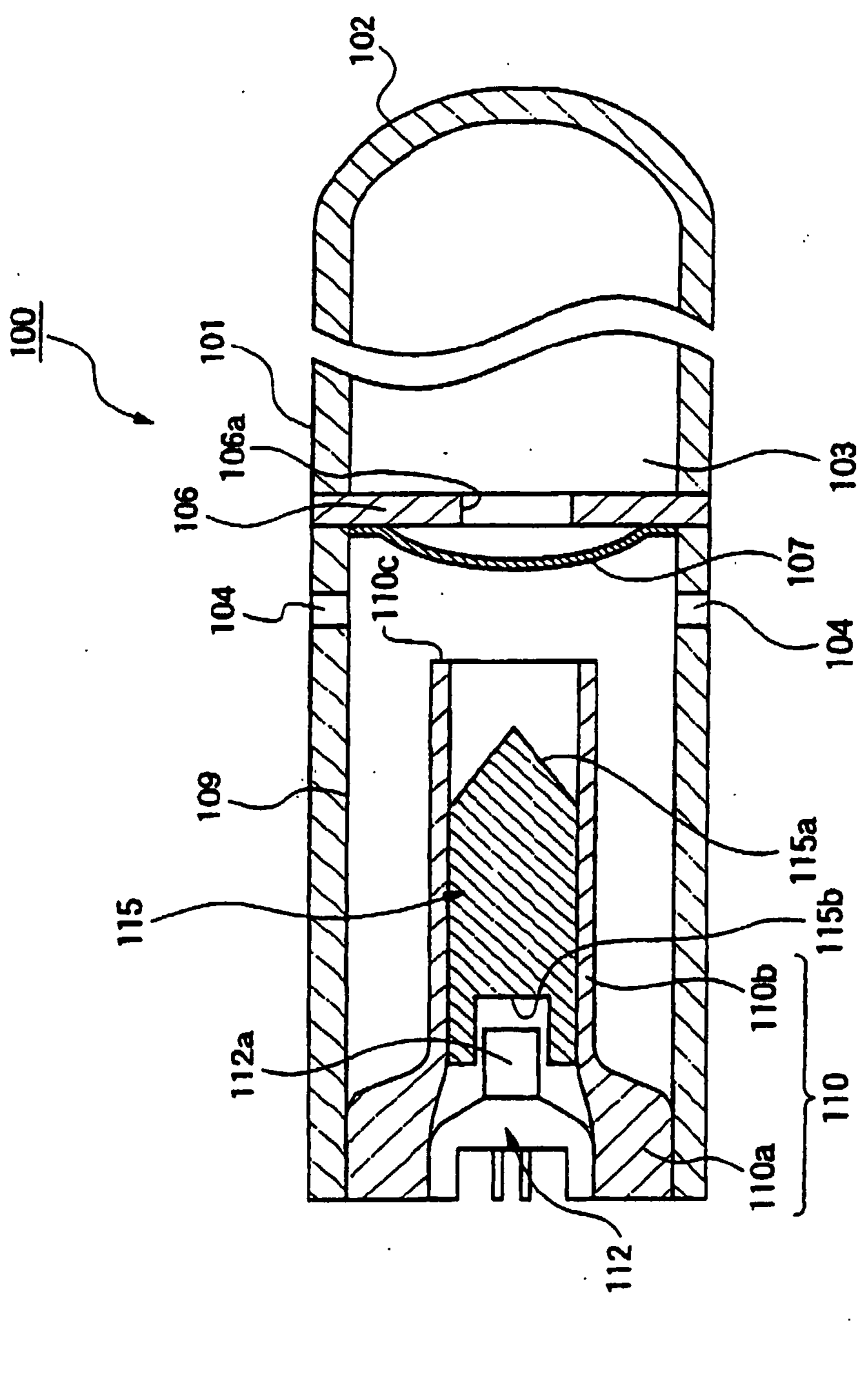
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Fig. 5

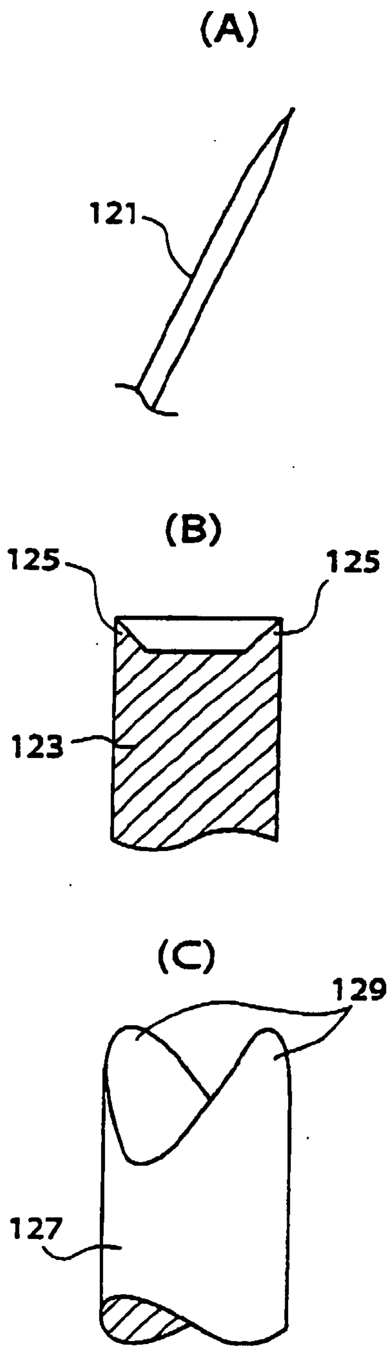

Fig. 6

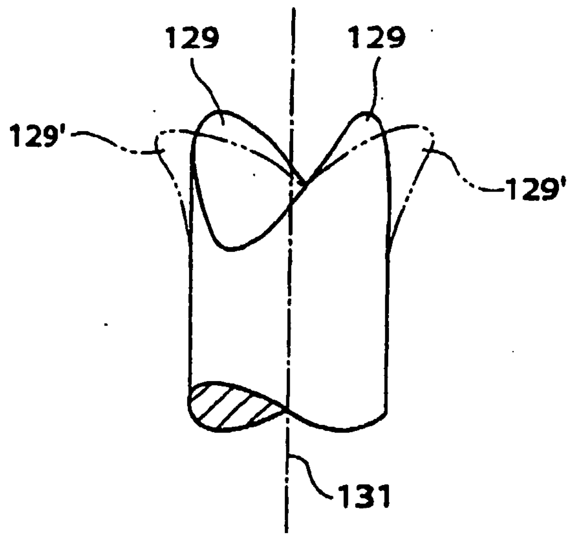

Fig. 7

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(54) **Inflator**

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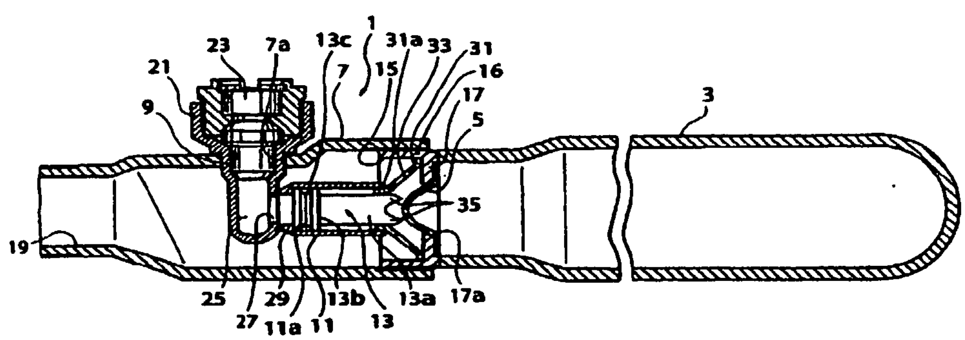

Fig. 1

EP 1 262 380 A3

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European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 02 01 0150

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X	US 5 242 194 A (POPEK JOSEPH C) 7 September 1993 (1993-09-07) * column 1, line 56 - column 6, line 25; figures 1-3 * ---	1,4,5	B60R21/26
A	US 5 601 309 A (BENDER RICHARD ET AL) 11 February 1997 (1997-02-11) * column 3, line 7 - column 4, line 67; figures * ---	1	
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